Chemistry 129.01 - General Chemistry Workshop - Spring 2017

Week #8

Friday, April 7. Equilibrium Constant Applications and Le Châtelier's Principle

Assigned reading: Sections 13.3, 13.4

Today we will continue our discussion about chemical equilibrium. We will work on more problems involving the equilibrium constant to determine the concentrations of reactants and products at equilibrium. Next week, we'll apply these equilibrium concepts to acid-base equilibria so that we can determine the pH of different solutions.

We will also discuss the Le Châtelier's principle. The Le Châtelier's principle is one of the most fundamental ideas behind chemical reactivity. This is our introduction to it and we will apply it again next week to common-ion strong and weak electrolyte solutions like buffers. The basic idea is simple – a chemical system shifts in response to perturbations to the system. What we need to understand is how we can perturb a system and how it will respond.

1. Define the following concepts and symbols:

   Le Châtelier's principle

   Exothermic Reaction

   Endothermic Reaction

2. What kind of disturbance will result in a change to the value of the equilibrium constant, concentration, volume or temperature?

3. This is the ideal gas law, PV=nRT where P represents the pressure, V the volume, n the number of moles, T the temperature and R is the gas constant. Based on the ideal gas law equation, how is the pressure of a gas related to the volume of a gas? How is it related to the number of moles of gas? (Directly proportional or inversely proportional?).

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Problem Set #9

Due Monday, April 10 (at the beginning of class). Late homework will not be accepted.

1. Write the equilibrium expressions (K_C) for the following reactions and indicate whether the equilibrium is homogeneous or heterogeneous.

   (a) $2\ O_{3\ (g)} \leftrightarrow 3\ O_{2\ (g)}$

   (b) $Ti_{(s)} + 2\ Cl_{2\ (g)} \leftrightarrow TiCl_{4\ (l)}$

   (a) $2\ C_2H_{4\ (g)} + 2\ H_2O_{(g)} \leftrightarrow 2\ C_2H_{6\ (g)} + O_{2\ (g)}$

   (b) $4\ HCl_{\ (aq)} + O_{2\ (g)} \leftrightarrow 2\ H_2O_{(l)} + 2\ Cl_{2\ (g)}$

2. Consider the following reaction:

$$CO_{(g)} + 2\ H_{2\ (g)} \leftrightarrow CH_3OH_{(g)}$$

An equilibrium mixture in a 2.00L vessel is found to contain 0.0406 mol CH_3OH, 0.170 mol CO, and 0.302 mol H_2 at 500K. Calculate K_c. Which reaction is favored (forward or reversed)?

3. Find K_C for the following reaction:

$$\mathbf{2NO_{2\ (g)} \leftrightarrow N_{2\ (g)} + 2O_{2\ (g)} \quad K_C = ?}$$

Use the following data to find K_C:

$\frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} \leftrightarrow NO_{(g)} \quad K_C = 4.8\times10^{-10}$

$2NO_{2(g)} \leftrightarrow 2NO_{(g)} + O_{2(g)} \quad K_C = 1.1\times10^{-5}$

4. A mixture of 1.374g of H_2 and 70.31g of Br_2 is heated in a 2.50L vessel at 700K. These substances react as follows:

$$Br_{2\ (g)} + H_{2\ (g)} \leftrightarrow 2\ HBr_{(g)}$$

At equilibrium the vessel is found to contain 0.566g of H_2. Calculate the equilibrium concentrations of H_2, Br_2, HBr and K_c.

5. At 100°C the equilibrium constant for the reaction

$$COCl_{2(g)} \leftrightarrow CO_{(g)} + Cl_{2\,(g)}$$

is 2.19×10^{-10}. Is a mixture containing the following concentrations at equilibrium: $[COCl_2]=2.00\times10^{-3}$M, $[CO]=3.3\times10^{-6}$M, $[Cl_2]=6.62\times10^{-6}$M? If not, indicate the direction that the reaction must proceed to achieve equilibrium.

6. Consider the following reaction at 400K:

$$Br_{2\,(g)} + Cl_{2\,(g)} \leftrightarrow 2\ BrCl_{(g)} \quad K_c = 7.0$$

If 0.25 mol of Br_2 and 0.25 mol of Cl_2 are placed into a 1.0L container, what will be the equilibrium concentrations of Br_2, Cl_2, and BrCl?

7. The following reaction is exothermic: $2\ Cl_{2\,(g)} + C_{(s)} \leftrightarrow CCl_{4\,(g)}$

I. Predict the effect (shift right, shift left, or no effect) of the following:

(a) Adding more CCl_4 to the reaction mixture: _____

(b) Increasing the temperature of the reaction mixture: _____

(c) Adding more C to the reaction mixture: _____

(d) Adding more Cl_2 to the reaction mixture: _____

(e) Decreasing the volume of the reaction mixture: _____

(f) Adding a catalyst to the reaction mixture: _____

II. Will the equilibrium constant of the reaction increase or decrease if the temperature is increased?